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SECTION OF GEOLOGY AND MINERALOGY

THE SCIENCE OF SNOW AND AVALANCHES

By PAUL NIGGLI*

The petrologist distinguishes three main types of rock, according to their manner of formation. They are known as igneous, sedimentary, and metamorphic, respectively. Important clues as to the origin of these fundamental units of the lithosphere may be gained by the study of processes which are directly observable. Thus, in volcanic areas, we can study the phenomena that accompany the formation of rocks from the molten state; the deposition of sediments can be followed on the seashore and on the mainland; while processes of weathering and coal formation give an understanding of metamorphism.

In intercontinental mountainous countries like Switzerland, observations on *ice* and *snow* offer new possibilities for gaining insight into processes of petrological importance. Such processes are comparatively easy to understand, as only one substance is involved. The formation and vanishing, the deposition and transport of this crystalline solid can be studied during the course of each year, and, on account of their importance for water supply, snowdrifts and avalanches deserve the most careful attention.

* Zurich, Switzerland. This lecture, illustrated by lantern slides and motion pictures, was presented at the meeting of the Section on January 5, 1948.

The formation of ice coating on a water surface shows that a liquid or melt can, on cooling, solidify to a compact crystal aggregate. Taken in connection with observations made in volcanic areas in which molten magma from the interior of the earth consolidates to form rocks, we are left with no doubt that crystallization from melts is an important factor in rock formation. In particular, the study of the ice cover shows clearly that, when undercooling takes place and sudden crystallization simultaneously sets in around many nuclei, the individual crystal is unable to freely develop its characteristic shape, but may nevertheless assume a definite orientation in respect to the surface of cooling. Taking into account the peculiar properties of water, we learn to appreciate the importance of the rate of crystallization, the accompanying change in volume, the temperature gradient, the amount of melt, and the nature of the convection currents.

A far more vivid insight into the processes of crystallization is provided by falling snow. It permits us to study the growth of crystal nuclei or groups of nuclei to form snow stars and snow flakes and the myriad-fold repetition of a process remaining constantly the same in principle, though varying in detail. The variability of the observed forms seems unlimited and it is only by concentrating on essential

This number contains the announcement of the A. Cressy Morrison and George Frederick Kunz prizes for 1948 (p. 159).

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features and applying statistical methods that the existence of certain common traits in development can be detected. In this respect, we are dealing with quite a characteristic problem of natural science, namely, that of bringing individual and generally typical properties into line with one another.

This particular case is concerned with a crystallization out of water vapor and water drops. Depending on the circumstances of formation and the prevailing atmospheric conditions, the following products can be distinguished:

(1) Preponderantly acicular or prismatic crystals, single or in aggregates.

(2) Preponderantly tabular crystals with the dominant plane perpendicular to the elongated axis of the prismatic crystals. Such crystals, two-dimensional for all practical purposes, often possess a thickness of about one thousandth of a millimeter and very often show dendritic star-shaped forms.

(3) Complex aggregates in which both prismatic and tabular crystals participate.

(4) Rounded crystals or crystal aggregates and products of quite irregular shape.

If, as happens very frequently, crystallization out of the water vapor of the atmosphere sets in suddenly as a result of undercooling, chains of molecules rapidly attach themselves to each center of crystallization according to the chief bonds and parallel to the six symmetrical directions in the basal nets of the ice structure. The points that are formed attract further molecules and growth takes place in an outward direction. The inner parts are frequently not completely filled in, as the points prevent sufficient material from reaching them.

Thus, six chief branches at angles of 60 degrees to each other shoot out from the center to build a dendritic snow star. Side branches of the first order can grow out of these chief branches only when the points of the latter have moved sufficiently far apart to allow diffusion out of the surrounding medium to set in and the critical point of supersaturation to be exceeded. Side branches are, therefore, lacking near the center. Their opportunity to grow is limited, as they extend into the same space as the side branches of neighboring chief branches. The profusion of forms observed is the result of irregular diffusion and mutual interference. The slightest change in supersaturation and temperature produces alterations within the limits laid down by the structure of the patterns capable of growing and being preserved. Falling snow in calm weather thus is a crystalline precipitate on a large scale. Gravity in conjunction with the size and shape of the crystals determines the rate of fall, which may vary from a few centimeters to over two meters per second. The process of sinking is, therefore, comparable to the deposition of sedimentation of salts out of evaporating sea or salt water. Just as deposits of gypsum or rock salt collect at the bottom of standing water, so the accumulation of falling snow on the uneven surface of the earth produces a snow cover which no less than the examples mentioned is a crystalline aggregate, a rock.

The fabric to which these variously shaped crystals give rise is, at first, felted, powdery and very loose, with poor internal cohesion. When it has piled up on a steep slope, it can slip down, much as a heap of feathers might do. Such avalanches are called powder, wild snow, or new snow avalanches. More than 90 per cent of the volume of newly fallen snow is interstitial space filled with water-saturated air. The snow rock possesses an enormous so-called absolute porosity and a low bulk specific gravity. One cubic meter of powder snow formed at low temperature and under calm conditions weighs only 50 to 100 kg. Wild snow is even lighter, weighing but 25 to 50 kg. Certain modifications of these data frequently occur, for instance when, as so often happens in the mountains, wind or snow storms tend to shake down the snow, to split up the branches of the stars, and

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thereby effect a tighter packing. By storm and drift, grains become wedged between other grains and jam themselves tight. Under conditions of snow-drifting, the powder snow is replaced by wind-packed snow weighing 100 to 500 kg. per cubic meter. That also leads to a consolidation similar to the hardening of sand under wind action. Moist wind may also produce a sort of firnification by condensation of water vapor between the grains. So-called wind slabs may ensue, or surface features such as cornices develop on the leeward and also on the windward side of ridges and slopes. Some of the forms of the wind slabs may resemble those observed among sand-dunes and in sand deserts, and are a counterpart to these aeolian sediments.

The sciences of glaciology and avalanches, with snow as the fundamental material, were established in the 19th century in the alpine countries, especially in Switzerland. One of the leaders in this classical period was Louis Agassiz, later a distinguished scientist in the United States. Another was the forester, Coaz. Curiously enough, mineralogists and petrologists have until recently given little attention to the snow rock as such, that is, to the stratified mass resulting from different snow falls in a winter season. During the last ten years, great advances in the science of snow and avalanches have been made in the United States, in Canada, Austria, Germany, Scandinavia and Russia, and also in Switzerland. Paulcke and Seligman were pioneers in studying the dangers of avalanches for the skiers in the Alps. An international committee with Prof. Church at its head was founded. We have a classical example of fruitful cooperation between pure and applied science in the fact that it was, at least in my country, the formation of avalanches, one of the greatest dangers of the high mountains, which provided the initiative for a closer study of the winter snow cover. Much scientifically valuable information has already been gained by observations on this seasonal rock which is formed, undergoes alteration, and disappears.

The layman's conception of mineral aggregates as being everlasting and unalterable proved to be untenable even in the case of silicate, carbonate, and salt rocks. It has even less justification in connection with snow deposits. It was one of the chief tasks of the observatories in the high mountains to unite theory, experiment, and observation of nature in studying the properties and alterations of the snow cover during the winter season.

The looseness of the aggregates and their low melting-point called for specially adapted methods of investigation which, for the most part, had to be developed first. It is, of course, impossible to collect hand specimens of the snow deposit and remove them for investigation to a laboratory at lower level, as we do with ordinary rock specimens. Nor can thin sections in the ordinary sense be ground and examined under the microscope. A refrigerated laboratory in the high alps, at a level corresponding to that of avalanche formation, was essential. Specimens in undisturbed positions had to be collected with the greatest care by means of cylindrical snow sondes (hollow steel-tubes of suitable size), and submitted to immediate examination. The sondes are pushed or driven in vertically or parallel to the surface so as to obtain samples of different layers of snow or of one only. Special techniques for making thin sections, analyzing grain size fractions with sieves and a sedimentation balance, and for determining the weight of unit volume, the penetrability and cohesion had to be worked out. Within a trial field, profiles had to be made constantly and at regular intervals and reduced to time profiles, so that all changes in the snow cover could be studied on the spot. One of the chief results is the following:

During the snowfall itself, but especially after the snow has been deposited, a radical alteration takes place which, in the course of time, changes the character of the

snow cover. The sediment undergoes metamorphism and develops a completely new fabric with new mechanical properties. New snow is transformed into settling snow, settled snow and, finally, old snow of variable character and with changing degrees of composition and adhesive resistance of the grains. A stratification of the deposit, depending on the climatic condition during and between the individual falls of snow, is brought about, and in many cases the course of alteration can be predicted well in advance. This is important as the formation and type of avalanches depend on the character of this stratification. The study of the behavior of the alpine winter snow cover thus becomes the most impressive example of the metamorphic processes to which so many rocks owe their appearance. In this case, it has the inestimable advantage of unrolling itself before our own eyes.

The primary cause of snow metamorphism lies in the possibility of settling, in the instability inherent in the complex forms developed by the snow crystals during their all-too-rapid dendritic growth. Once deposited and covered, the crystal of new snow is surrounded by an atmosphere possessing only average saturation with water vapor. The sharp points and strongly curved surfaces do not completely retain the molecules which again go into the vapor space or creep along the surfaces to attain other positions. Thus, the surplus of surface energy which distinguishes skeletal forms from closed polyhedral single crystals manifests itself. A redistribution of matter leading to a reduction of total surface area sets in and can be followed by cinematography. This constitutes the formation of granular snow. It proceeds faster at higher temperatures than at lower ones; hence, only at the latter can powder snow retain its loose felted character for considerable time. Near the freezing point, the effect of surface tension seems to manifest itself up to surface radii of at least 100 to 200 microns. Fallen snow has, therefore, the tendency to settle and recrystallize and to attain an increased cohesion due to the loss of the felted texture. The rate of change in frost is a function of the temperature, which itself varies in the snow cover from point to point and also in time.

Daily observations of standard cross sections in a given snow test field give a detailed insight into the variation in temperature on, within, and below the snow cover. As an average of all daily observations, it can be stated that in the high mountain region the surface of the snow normally shows the lowest temperature (often —10 to —30 degrees C.) at about 8 a.m.; with increasing depth in the snow cover, the temperature of the snow rises rapidly at first and then with increasing slowness. The average temperature of the air measured 10 m. above the snow surface often corresponds to that of the snow at a depth of 10-20 cm. below the surface. The temperature of the boundary layer between the hard pan and the snow cover varies in the studied regions between 0° and —2° C. during the whole winter. The temperature gradient in the snow cover thus depends on the air temperature, the daily variations of this temperature, and the thickness of the snow cover and its exposure. The temperature of a given layer changes its value during the day and night, according to weather conditions and also when a new snowfall takes place which enlarges the total thickness. The mean density of the whole snow cover rises after the first abundant snowfall, but the different layers tend to different densities depending on the snow conditions, the meteorological phenomena, and the different temperatures within the cover. In the Swiss Alps above 2000 m., the total weight of the snow cover reaches a maximum towards the end of the winter, because during mid-winter the melting point is never reached at points situated somewhat below the snow surface. The transformation of new into old snow of generally fine-grained character takes place

without the participation of a liquid phase. Only as the result of intense sun heat can snow melt superficially, later to be refrozen into a so-called sun crust resembling firm snow lying on softer snow.

These relatively thin surface layers of a fine weather period without snowfall are generally well consolidated, but nevertheless by no means stable as regards form. This is a consequence of the different orientation existing between the grains rounded by melting and the mass in which they are embedded. Other surface layers are formed by sublimation after nights of low temperature and clear sky, and are called surface hoar. Other films or crusts of hard snow lying upon a softer layer, like spring crust or rain crust, generally occur in the higher mountains only in the spring. Below these small layers, the settling and metamorphism to ordinary granular old snow goes on. If a new snowfall now covers the sun crust or a surface hoar layer, all conditions under the new burden are changed and the metamorphism of the deeper layers makes a new start. Often, by collective crystallization, the unstable small surface layers of the earlier snow layers produce grains of large, fairly idiomorphic, cup-shaped appearance, whose cohesion is practically nil (loosening of the crusts). Such formations are called depth hoar and behave like quick or shifting sand. It is evident that the comparatively high temperature prevalent in layers near the earth's surface will often also cause them to undergo changes of this kind. But generally, during the first days after a heavy fall of new snow, all that takes place is a loosening of the upper part of the old layer and a progressive hardening and consolidation with recrystallization just below these crusts.

In this way, and depending on weather, exposure, temperature, snowfall, and the type and rapidity of the metamorphism, a banded structure or stratification tends to develop during the winter, which is due to alternating layers of snow showing varying compactness, strong and weak cohesion, and different grain size. By taking driving diagrams with a pile driver or rammer, we can easily distinguish between the layers of different cohesiveness, and, by studying one layer during the whole season, we obtain an insight into the course and rate of metamorphism and can compare this with the meteorological conditions.

The different layers, all of the character of crystal aggregates, have in common with all solids a certain tensile pressure and shearing strength as well as plasticity. When, as in the mountains, the snow is deposited on very uneven surfaces, the influence of gravity naturally produces strong strains within the sloping snow cover. In a porous aggregate (even old granular snow has pores amounting to 50 per cent of the volume) filled with a gas phase under hydrostatic pressure, the distribution of these strains will be a peculiar one and will also exercise an important influence on the processes of recrystallization and mechanical deformation. At first, a redistribution of material, tending to ease the strains, will take place. One special manifestation of this tendency is a rise in the vapor pressure near the surface of grains under stress to values above that of normal saturation. The surface of contact between different grains is only a very small part of the total surface. This may lead to crystallization from the supersaturated vapor phase, whereby a redistribution of matter within the snow mass may ensue. The same phenomena are found in stressed silicate rocks under higher temperatures and are one of the reasons for dynamometamorphism. In another special case, crystal plasticity within and between the grains may become operative and result in yielding by translation to the stress. In the first instance, lattice layers of individual crystals are translated along each other. Slipping takes place on the crystallographic plane (1,000) and along certain crystallographic directions. In the second case, crystals, as

a whole, glide or rotate over other crystals and the combination of intra- and inter-crystalline plasticity is characteristic of a polycrystalline aggregate. The inherent tendency to lattice translations in snow crystals (and hence their crystal plasticity) and also the mobility of the grains are, to a remarkable degree, dependent on temperature. This is proved by the creaking of snow on cold days, due to increased hardness and brittleness. Near the melting point, however, translations and gliding produce a complete rearrangement combined with a regulation of the fabric similar to that observed in the annealing of metals and in crystalline schists.

On the whole, however, the behavior of snow in the neighborhood of and somewhat below 0° C. under static load is in many respects more analogous to that of a viscous liquid, with high internal friction. In connection with sudden dynamical forces, the effects of elasticity are also important. The movements of snow layers on a slope can often be treated like the surface flow of glaciers. The most important difference is the porosity of the snow, the more homogeneous layered structure, and the freedom of the fabric which ensures a greater mobility of the grains themselves.

Of course, the micromechanism of creep and flow or, generally speaking, of plastic deformation in this transparent polycrystalline material, is very complicated and not yet known in detail. But to obtain a general survey, the effects can be summed up in terms of the coefficients of viscosity or toughness indices. It is then seen that the viscosity generally increases from felted snow to fine-grained and coarser-grained snow. The viscosity increases with sinking porosity and, to a large measure, with sinking temperature. It seems that the order of magnitude of the coefficient of viscosity (between 0° and —40° C.) is 10^{10} to 10^{15} for different dry snow layers, corresponding to a time of relaxation of 10^{1} to 10^{6} seconds.

The modulus of elasticity for granular snow at the temperature of —10° C. is of the order of magnitude of 10^{5} kg. per square meter. For compact ice, the value of 10^{8} kg. per m.^{2} has been determined.

In order to obtain information about all the mechanical properties of the different layers of a snow cover, methods and terms similar to those used in metallurgical engineering and technical petrography must be employed. Undisturbed test specimens of snow in cylindrical form are subjected to the action of progressively increasing load or tensile pull until they break. In a rotational apparatus, values of the "strength" are obtained. The deformation of the polycrystalline aggregate and the response of a snow layer to applied forces must be studied. With creep test methods, the effects of temperature, porosity, and microstructure, of crystal size on deformation and on the resistance to deformation can be studied. On slopes with different angles of inclination, the creeping-pressure is measured, which, of course, is necessary for the construction of the different types of counter-avalanche defenses (rows of retaining-walls or isolated "resistance elements"). It is found that the strength against tensile stress is greater if porosity and temperature are low. Maximum values are often found in fine-grained snow and lower ones in felted, newly fallen snow or coarse-grained old snow.

Under natural snow conditions, the various effects will be superimposed on each other and contribute to the general and differential plasticity and strength of the layers of the snow cover. The varying properties and anchorage of the different layers in respect to the lower ones tend to disturb the uniformity of the phenomena of creeping which can be observed on slopes, and sliding friction between the various metamorphosed layers assumes different values. Naturally, various rates of creeping set in and cause longitudinal strains, generally also a zone of tension in the upper parts and one of compression

in the lower parts of an inclined snow field, while along firmly anchored lines zones of shearing occur. Ultimately, when the strains in a particular layer have risen to values near the yielding point, an extremely labile equilibrium remains. Very insignificant factors such as a small breakaway of snow or a new snowfall with its pressure excess, now suffice to produce sudden enormous increases in the strains and lead to the formation of avalanches. In the case of the particularly dangerous snow slab avalanches, consolidated upper layers glide over others which, loosened by metamorphism, act as a lubricant over a glide plane. By taking, every day, sonding tests with the rammer and taking the weather conditions into account, an estimate can be made of the likelihood or otherwise of the occurrence of avalanches which are dangerous chiefly on account of the mass of material set in motion. In the case of a dangerous situation, not only can warning be given, but the possibility exists of producing avalanches artificially with explosives or by shooting down the snow in small portions before a great accumulation has taken place. In the last war, an avalanche service was introduced in the Swiss army with the effect that the concentration of troops in the Alps for defense work was carried out with practically no accidents.

Many important details of the development of slip surfaces can already be sharply formulated, but the indications made will suffice to show that a study of the conditions for the metamorphism of the snow cover, and the course taken by it, together with a thorough knowledge of the mechanical properties of the structurally different sorts of snow, is an essential prerequisite for a scientific treatise on avalanches. Laboratory work entailing an exact characterization of every kind of snow, and determinations of the gradation of grain size (elutriation and sedimentation balance), packing, and pore space in relation to the mechanical properties are necessary.

Another very interesting part of the researches relates to the thermal economy or heat balance of the snow cover. It comprises the sum of gains and losses of all heat currents which pass the boundaries of the layers (heat current through the base of the snow, conduction and radiation within the snow cover, radiation balance on the surface, exchange of heat with the surrounding air by conduction and convection, exchange of heat caused by condensation and evaporation processes).

Especially, the radiation balance on the surface is dependent on the vertical component of the solar radiation, the longway heat radiation coming in from the atmosphere or the clouds, and the outgoing radiation from the snow cover.

The radiation from sun and sky which reaches the snow cover is partly reflected (often more than 50 per cent) and partly transmitted by absorption. The absorption coefficient rises as the settling and compactness of snow increases. All bodies become athermanous to radiation at a certain thickness; for snow, a thickness of about 50 cm. suffices. The reflecting power was measured by means of a suitably mounted thermopile and a photoelement. Knowledge of the reflecting power permits the calculation of the amount of radiation absorbed per square centimeter of the snow cover, when the values of the sun and sky radiation incident on the horizontal surface are given.

In spring, the intensity of the radiation, the length of the days, and the height of the sun and the absorbing power in the upper part of the cover greatly increase, while the reflecting power of the snow simultaneously decreases. From this, it is clear that the amount of radiation energy absorbed daily by the snow cover must strongly increase from mid-winter to spring. In winter itself, the snow cover is hardly affected by radiation during fine weather, while toward spring it is melted, the process of melting chiefly taking place on the surface of the snow.

As a rule, the entering radiation predominates during daylight and the radiation balance is negative at night. The total exchange is, of course, greater under a clear sky than under cloudy conditions. At night, the temperature of the radiating body falls and the amount of the negative radiation balance sinks from evening towards morning. Snow possesses low absorbing and high reflecting power for short wavelengths. On the other hand, it absorbs long-wave radiation almost like a black body. Its thermal conductivity is low. Snow thus belongs to the bodies which at all times show a low radiation exchange. Ice lies between water and snow in respect to the radiation balance.

The amount of heat, in calories, necessary to raise the temperature of a snow column of 1 cubic centimeter section to 0° C. without melting the snow is called the *cold content*. This amount depends on the thickness, the fabric and porosity of the snow column, and the temperatures within the column. Generally, the heat of fusion is 20 to 50 times greater than the cold content in a snow cover at 1500 m. above sea level in winter time.

From the thermal economy it follows that the mainly dry metamorphism of the alpine winter snow cover is complicated towards spring by melting and thawing processes. Water soaks the snow. This can be the cause of wet snow avalanches and ultimately leads to the complete disappearance of the seasonal rock. In the region of so-called perpetual snow, similar processes (in conjunction with the temporary presence of the liquid phase) lead to the formation of firn and, finally, to the practically compact glacier ice. The individual grains first melt at the corners and edges so that further settling and closer packing result. Old firn-ice has an absolute porosity of only 50-33 per cent, while glacier ice is often altogether lacking in communicating pores. The horizons of dirt appearing in firn ice are produced by rock fragments transported by the wind and deposited on the snow cover. These fragments may, during melting, sink in to a depth of several centimeters. Bands of a more compact nature appear as so called "blue bands." They are, in a sense, cementation zones deriving from melt water percolating downwards and often possess a regulated fabric, the chief axis of the ice crystals being generally perpendicular to the banding. It is interesting that the apparent viscosity is many times greater in frozen snow, possessing no preferred crystal orientation, than in a polycrystalline block, where all the crystal glide planes are more or less parallel to the direction of shear.

Many details of what takes place still have to be worked out, and even our conceptions on the movement of glaciers must be revised from the standpoint of crystallography and the modern science of plastic flow in polycrystalline aggregates. To this end, not only the snow and avalanche station on Weissfluhjoch, but also the research institute on Jungfraujoch are engaged in studying this much more drastic type of metamorphism by all the methods of modern science. Swiss glaciologists are working together with the Cambridge glacier physics committee. It can confidently be expected that the snow and ice rocks will, in spite of their simple chemical composition, also furnish a valuable contribution to our knowledge of the process called ultrametamorphism, to which, at present, petrographers are devoting much attention. Rocks originally formed by the consolidation of magmas or by sedimentation are, during the course of major tectonic disturbances, subjected to totally new conditions whereby they also undergo changes. Under the influence of rising temperatures they may, in full analogy to snow, wholly or partially revert to the molten state. Further changes in the outer factors may then lead to a renewed formation of solid crystal aggregates. The mutual relationships between crystal and melt can, in part anyway, be elucidated by the study of wet snow, firnification, glacier formation, and glacier

movement. They provide a check on and a correction of the theories and conceptions advanced by the students of magmatite formation.

It may, thus, truly be said that the science of snow, while using the methods of crystallography and mineralogy and physics of the solid state, provides many a valuable insight into the problems of these very sciences. For countries in which villages and towns have arisen in the high mountains, in which roads and power stations are being built, in which winter sports flourish and the army has to defend mountain passes—for these countries, efforts to avoid the dangers of avalanches are a vital necessity. With this end in mind, the research station on Weissfluhjoch near Davos in Switzerland was founded. Some aspects of the work done by our collaborators, especially by Professor Bader, Drs. Morikofer, Winterhalter, Haefeli, and de Quervain, Engineer Bucher and the assistants Thams, Eckel and Roch have been recorded in lantern slides and a short film for demonstration purposes.

SECTION OF BIOLOGY

ESSENTIALITY OF CONSTITUENTS OF SEA WATER FOR GROWTH OF A MARINE DIATOM

By S. H. HUTNER *

The growth requirements of marine organisms higher than bacteria are poorly understood. Knowledge of the ionic relations of marine forms may assist in testing the theory that the electrolyte balance necessary for the functioning of mammalian tissue is a reflection of the pattern imposed on protoplasm by its origin in the ancient less saline sea—a hypothesis fascinatingly sketched by Baldwin.[1] The inshore diatom *Nitzschia closterium,* isolated in England nearly forty years ago, has been studied intensively, and was therefore chosen as the starting point of this investigation. The relation of this older work to general oceanographic problems has been summarized by Harvey.[2]

Only guide-post data are presented here, but as the *methods* being developed to evaluate the role of each constituent of sea water appear widely applicable, emphasis will be placed on the theoretical foundations of the procedures, and experimental results are cited mainly to illustrate these methods. The conclusions drawn from these results are highly tentative. Much information has accumulated, but more quantitative data are needed before clear-cut principles can be formulated.

Methods. A bacteria-free subculture of the classical strain was obtained from Professor E. G. Pringsheim. Stock cultures were maintained on 1 to 2 per cent sea salt (a convenient substitute for diluted sea water)—peptone agar slants, pH 7.1 to 7.7, in screw-capped tubes. Peptones of the tryptic digest of casein type (trypticase or tryptone) allowed heavy growth at the 0.1 to 0.5 per cent levels. Cultures remained viable for at least a month when stored in darkness at 6° C. Experimental cultures were grown in 25-ml. Pyrex Erlenmeyer flasks, plugged with Pyrex glass wool. Illumination and the proper temperature (18° to 20° C.—this is close to the upper limit) were secured by placing the flasks on glass trays in a refrigerating incubator (Central Scientific Company) equipped with two 20-watt "soft white" fluorescent lamps. Growth was rapid under these conditions, and was measured after 25 to 35 days. Otherwise the procedures were similar to those previously described.[3]

Results with Citrate. Work with enriched synthetic sea water media is hindered by the formation of precipitates. These, by absorption, remove essential elements, as indicated by the repeated observations of other workers that filtered solutions do not support growth. In devising substitutes for sea water, it early became apparent that calcium, magnesium, and iron were required in rather high concentration, each inducing precipitates at pH 7.0 and higher. The use of citrate overcame this difficulty. Citrate forms soluble chelate complexes with many elements, but in so doing removes them from the field of action. The formation of the calcium citrate complex is illustrated in FIGURE 1. As the citrate concentration is increased, greater proportions of certain essential elements are bound, and it becomes necessary to adjust upwards the concentrations of these elements. By supplying an excess of all essential elements save one, one may then plot the increment of this element required to compensate for each increment of citrate. Then, by extrapolation to zero citrate, it is possible to arrive at a value closer to the *absolute* requirement for a particular element. This procedure applied to calcium and magnesium is illustrated in FIGURE 2. It is impractical to set up experiments with no citrate because of the formation of precipitates already

* Haskins Laboratories, New York, N. Y. This paper, illustrated by lantern slides, was presented at the meeting of the Section on January 12, 1948.

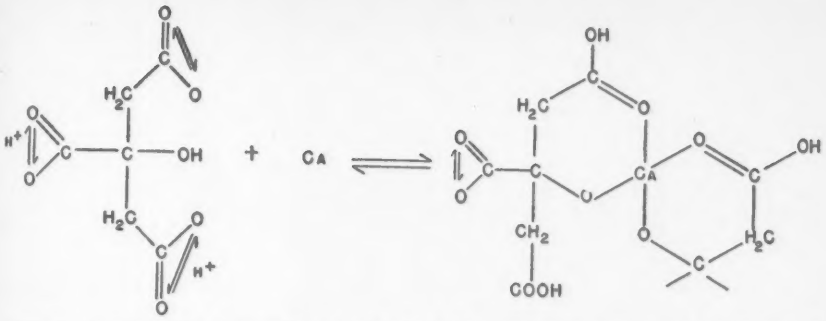


FIGURE 1. Possible manner of formation of chelate rings in the calcium citrate complex. One calcium ion may coordinate with more than one molecule of citrate. In this and the subsequent figures, only a limited effort is made to depict interatomic bond distances accurately.

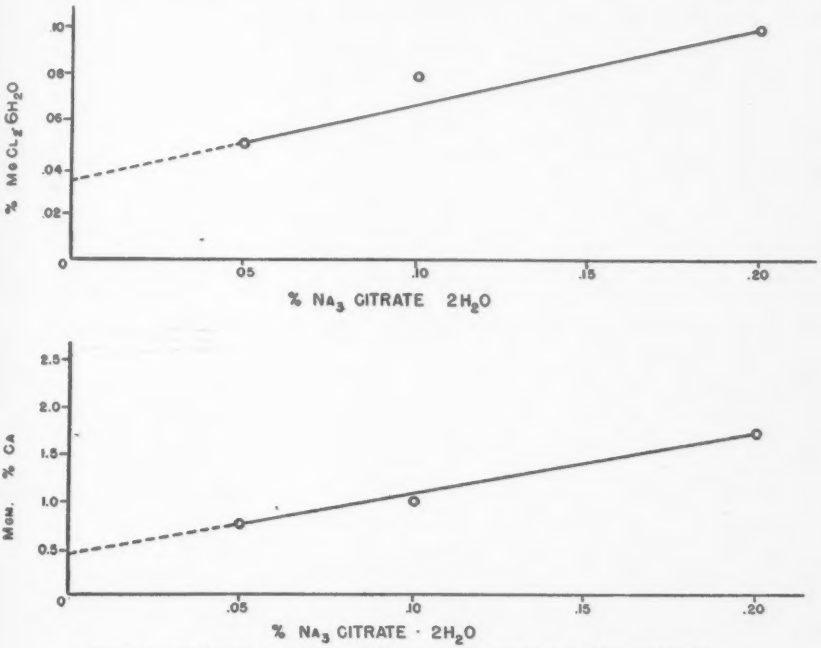


FIGURE 2. Calcium and magnesium requirements as a function of citrate concentration.

mentioned. The points plotted represent the amount of metal (or salt) that must be added to restore half maximal growth.

Before accepting these "absolute" values, it is necessary to define the experimental conditions rigorously. One way to test the accuracy of these values, obtained by what may be termed the citrate extinction technique, is to determine whether other complex-forming reagents, yielding curves different in slope, yield the same intercept as the citrate curve when extrapolated to zero reagent. For this purpose, the tartrate, oxalate, and other complexes are under investigation. Additional requirements for rigorous accuracy can be posed:

different non-toxic salts of the element in question must furnish the same intercept; furthermore, when a salt of the element is purified by at least two independent methods, both must furnish the same intercept. Meeting these conditions entails much tedious work but appears to be necessary to keep impurities in commercial "chemically pure" substances from seriously influencing the results. The satisfaction of these requirements for accuracy appears well on the way to fulfillment for calcium and magnesium, but is more remote for iron and manganese. Here, the situation is complicated by simultaneously induced deficiencies in molybdenum and other trace elements. Methods are being devised for each of the constituents of the culture medium, and it is likely that these purified materials will lead to reproducible results. The citrate extinction technique is an extension of the procedure employed by Hopkins and Wann[4] for determining the iron requirement of the green alga *Chlorella*. TABLE 1 shows the type of medium used for obtaining "extinction" data. It allows very heavy growth. The concentrations of nutrients are adjusted to the level of citrate shown in the table.

TABLE 1

SYNTHETIC MEDIUM FOR *Nitzschia closterium* *

K_2HPO_4	0.04%
NH_4NO_3	0.05%
Na_3 citrate.$2H_2O$	0.1%
Na metasilicate.$9H_2O$	0.005%
NaCl	0.2%
$MgSO_4.7H_2O$	0.25%
Ca (as $CaCO_3$ + HCl)	3.5 mg.%
Fe (as Fe + HCl + HNO_3)	0.5 mg.%
Boron (as H_3BO_3)	0.05 mg.%
Zn	0.005 mg.%
Mo	0.005 mg.%
Cu	0.005 mg.%
Mn	0.00005 mg.%

* pH 7.2-7.5. Because of toxicity, Mn, while essential, must be kept low.

On consideration, the citrate extinction technique is recognized as a special case of the method of competitive inhibition now widely exploited as a tool for finding new antimicrobial agents. But here the interference is with essential inorganic metabolites rather than with organic metabolites, and the mechanism is one of interception of the essential element rather than "jamming the lock" based on structural homology. This method provides a means of minimizing the importance of chemical contamination of the environment, by exaggeration of the requirement for a specific element or group of elements. Analogously, the discovery of the ubiquitous and highly potent growth factor, *p*-aminobenzoic acid, would have been much delayed if it had not been brought into the open as the most powerful antagonist of the sulfonamides. If there are essential trace elements yet to be identified, this method might facilitate their discovery.

The Sodium Chloride Requirement. Like most marine microorganisms, *N. closterium* poorly tolerates solutions more hypertonic than sea water. As the citrate concentration was increased, it was possible (and necessary) to decrease the NaCl to low levels, and even virtually eliminate chloride. It was not possible to obtain growth with concentrations of sodium below 0.02 per cent or so, a finding in harmony with some older conclusions.[5] A medium developed for this series of experiments is shown in TABLE 2. Comparison of it with the medium of TABLE 1 indicates the liberties permissible in abandoning sea water media.

TABLE 2

SYNTHETIC MEDIUM FOR DETERMINATION OF SODIUM CHLORIDE REQUIREMENTS *

K_3 citrate.H_2O	0.15%
NH_4NO_3	0.04%
$(NH_4)_2HPO_4$	0.03%
$MgSO_4.7H_2O$	0.3%
ethyl silicate [$(C_2H_5O)_4Si$]	0.004%
Fe (as $FeSO_4.7H_2O$)	0.5 mg.%
B (as H_3BO_3)	0.1 mg.%
Mo [as $(NH_4)_6Mo_7O_{24}.4H_2O$]	0.001 mg.%
Zn (as $ZnSO_4.7H_2O$)	0.001 mg.%
Mn (as $MnSO_4.H_2O$)	0.001 mg.%
Co (as $CoSO_4.7H_2O$)	0.01 mg.%
Ca (as gluconate)	3.0 mg.%

* pH 7.4. The addition of Na_2SO_4, 0.06%, allows heavy growth.

Preliminary Conclusions as to Ionic Balances. The values in FIGURE 1 for the calcium and magnesium requirements are much higher than those usually found for non-marine organisms. The calcium requirement is of the order of that of the land plants, and may prove deeply significant in view of the importance assigned to calcium in controlling the permeability of all cell membranes.

Differential Permeability and Ion Accumulation. Many organic compounds bind metals tightly by formation of chelate rings. The metal is held in a ring by forces similar to those stabilizing aromatic rings.[6] Citrate is comparatively weak in this respect; greater avidity and specificity in binding elements, particularly those of the transitional series, is possessed by compounds imparting a high degree of resonance to the metal-containing ring. Truly extraordinary biological compounds of this type are the porphyrins, where iron is bound in heme compounds and magnesium is bound in chlorophyll. It is increasingly recognized that the maintenance of differential permeability and the accumulation of ions against a concentration gradient is closely linked to respiratory activity. The suggestion has been made that this respiratory activity is required for the formation of ion-binders of the chelate type.[7] Following this line of thought, the surface of the cell may be regarded as studded with receptor patches, constantly regenerated by energy derived from respiration. The *number* of these receptor sites would help determine the concentration of a particular ion that must be present in the medium to keep the cell alive and growing; and the *avidity* or *"stickiness"* of these sites would determine the ability of the cell to compete with various types of metal-binding compounds for the available supply of essential ions. These receptor sites must be present to abstract such elements as iron and molybdenum from sea water where they occur

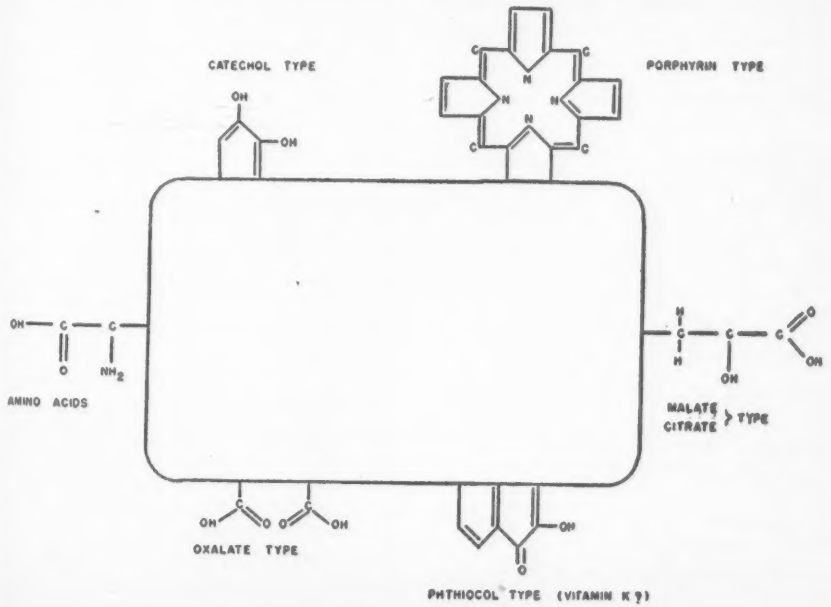
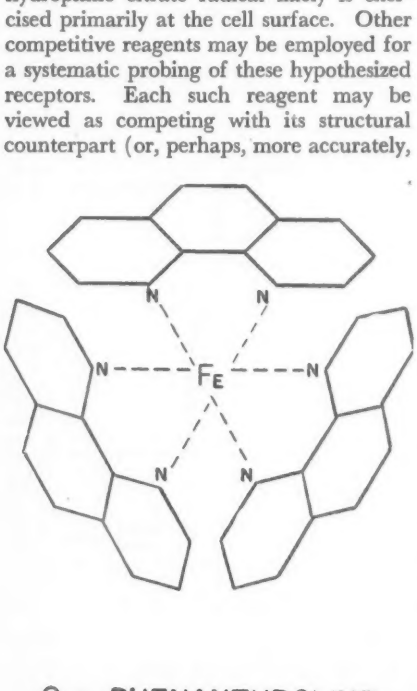


FIGURE 8. Cell with hypothetical metal receptorson the surface.

in almost immeasurably low concentration. The remarkable sensitivity and specificity which make certain chelating reagents so useful in the analytical chemistry of trace amounts of many metals, hint at the employment by the cell of this type of compound for similar purposes. Many components of the cell other than porphyrins and citrate are more or less effective metal binders: *e.g.*, α-amino and α-hydroxy carboxylic acids, glycerol, and other compounds with *ortho* configurations of potentially chelating substituents. This concept of the nature of the receptor sites for metals on the cell surface is diagrammed in FIGURE 3. Immunologists may recognize in these ideas an invocation of the shade of Paul Ehrlich.

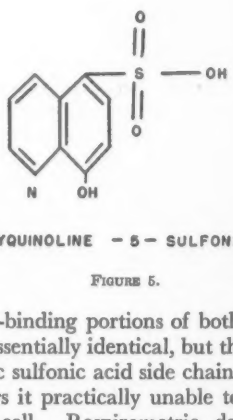
The competitive action of the bulky hydrophilic citrate radical likely is exercised primarily at the cell surface. Other competitive reagents may be employed for a systematic probing of these hypothesized receptors. Each such reagent may be viewed as competing with its structural counterpart (or, perhaps, more accurately, its electronic counterparts) embedded in the cell surface. Thus *o*-phenanthroline (FIGURE 4) binds iron and the adjoining transitional element of the periodic table in virtually the same kind of linkage characteristic of porphyrins. The question sometimes arises as to whether this competitive action, as distinguished from irreversible poisoning, takes place entirely at the cell surface, or whether there is also an appreciable penetration of the cell, with consequent interference with metal-catalyzed reactions within the cell. The answer may be sought in a comparison of the activities of pairs of chelators, alike in metal-binding capacity, but widely different in ability to penetrate the cell. Such a pair is 8-hydroxyquinoline and 8-hydroxyquinoline-5-sulfonic acid (FIGURE 5).



O – PHENANTHROLINE

FIGURE 4. The *o*-phenanthroline-ferrous complex. Double bonds in the *o*-phenanthroline are not shown.

8 – HYDROXY QUINOLINE



8 – HYDROXYQUINOLINE – 5 – SULFONIC ACID

FIGURE 5.

The metal-binding portions of both molecules are essentially identical, but the large hydrophilic sulfonic acid side chain on the one renders it practically unable to penetrate the cell. Respirometric data obtained in conjunction with growth data should be decisive in determining the extent of cellular penetration.

Little can be said at this time about the data obtained by these methods. Explor-

atory experiments with faster growing organisms such as *Chlorella* and photosynthetic and non-photosynthetic bacteria, indicate that these methods will eventually lead to a quantitative assessment of the requirements of *N. closterium* for iron, manganese, molybdenum, and, very likely, cobalt, and will even allow some well-informed guesswork as to the avidity of its receptors for various elements as compared with other microorganisms. The power and delicacy of this method is borne out by the provocative findings of Albert *et al.*,[8] who noted that cobalt overcame the inhibitory action of 8-hydroxyquinoline on gram-positive bacteria, but that iron plus zinc was required instead to antagonize the action of 8-hydroxyquinoline on gram-negative bacteria.

Diatoms and Other Biological Problems. There are additional objectives in work on *N. closterium* that can be touched on only briefly. Pelagic diatoms require for growth a factor in natural sea water that has, as yet, defied analysis. It is reasonable to suppose that information on *N. closterium*, which does not require this factor,[9] will facilitate investigations of the requirements of these more exacting diatoms. The diatoms belong to a great array of brown-pigmented algae whose energy metabolism has scarcely begun to be studied. Valuable sidelights on such problems as the nature of the energy stockpile built up by photosynthesis might be gained by a thorough-going search for substances permitting growth of this form in darkness. That this substitute for photosynthesis has to be unusually efficient is suggested by the finding that the mere maintenance of turgor in a marine diatom entailed the expenditure of considerable photosynthesis-gained energy.[10]

Viewed broadly, the object of this work is to contribute to the long series of experiments in other laboratories fashioning *Nitzschia closterium* into an effective tool for a wide range of investigations into cell physiology and comparative biochemistry. Because of the ever-present temptation felt by physiologists to confine their experiments to a few well-established laboratory organisms, there is always the danger that far-reaching conclusions may be based on too narrow a choice of living material. The manner in which a fundamental broadening of the theories of photosynthesis and hydrogen transfer waited upon studies of photosynthetic bacteria, complementing the time-honored green forms, is a striking example of the use of new organisms to clarify old problems. It is reasonable to suppose that the diatoms will be an increasingly valuable addition to the armamentarium of the cell physiologist, and thereby enhance the intrinsic importance they already possess as the equivalent of grass in the economy of the oceans.

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SECTION OF PSYCHOLOGY

THE NATURE OF SOCIAL PERCEPTION

By HADLEY CANTRIL*

When the term, social perception, was introduced into psychology a few years ago, I, for one, eagerly awaited a clarification of its meaning and anticipated that those using the term had some formulations that might help the social psychologist understand a few of the many mysteries he faces. I assumed that we would be told in just what way social perception was to be distinguished from our up-to-the-now understanding of the nature of perception itself.

So far, however, I know of no satisfactory attempt to clarify the precise meaning of the term that was coined, or to demonstrate its *special* functional significance in concrete situations. The phrase has kept pestering me so much that I concluded my subconscious must be groping for something important in its implications. At the same time, however, I felt certain that, if the meaning of "social perception" were clarified, we would find that it was basically the same as any other variety of perception and would follow the same underlying psychological principles even though there might well be some special characteristic involved that could give us useful insights.

It has become increasingly obvious, during recent years, that the psychology of perception involves a great deal more than analysis of laboratory experiments, no matter how important these experiments themselves may prove to be. The psychology of perception involves the whole field of attitudes and opinions, of judgments and belief. In our *Psychology of Ego-Involvements,* Sherif and I, for example, tried to show how the psychology of attitudes was rooted in the psychology of perception itself and to point out how much the social psychologist concerned with the nature and function of attitudes could learn from the experimentalist's rigidly controlled studies of perception and judgment. Since an understanding of human experience itself can be largely translated by the psychologist as an understanding of perception, its nature and determinants, it is encouraging for any psychologist who takes it upon himself to explain the behavior of men in concrete social situations to see that research into the nature of perception is currently advancing on a number of different fronts.

It is by no means original to point out that perhaps the most basic and crucial problem facing the psychologist is that of the precise causal relationship between perception and man's purposive behavior. In one way or another, it is this central problem that has engaged the attention of nearly every investigator whom most of us would agree to regard as outstanding in the short history of psychology. In spite of this, I am sure we also feel that only a beginning has been made. My discussion of the nature of social perception is offered here as a reflection of my own current groping for a more adequate and a more valid set of higher-order abstractions which may, eventually, give us a better understanding of the important causal relationship between what is traditionally referred to in psychology as "motivation" and "perception."

In the abovementioned volume, Sherif and I quite consciously left this problem hanging somewhat in mid-air. And for the past eighteen months, with what little spare time a teacher is able to find these days, I have been trying to answer in my own mind some of the questions that arise when one starts thinking about motivation and perception. I discovered that the

* Princeton University, Princeton, N. J. This paper was presented at the meeting of the Section on January 19, 1948.

hardest job, and the job that has to be done before one can even begin, is to ask oneself the proper questions.

As I began my investigation, I happened to learn almost by accident of the research on this very problem being done by Adelbert Ames, Jr., of the Hanover Institute. A brief discussion with Ames and a few hours with him to introduce me to the demonstrations he has devised during the last few years quickly convinced me that a more complete understanding of the implications of his demonstrations could be of more immediate help to me in straightening out my thinking than anything else I might do. I was, and remain, convinced that Ames is several jumps ahead of the field in his formulations; so much so, in fact, that, as so often happens in the history of science, either the real significance of his work is not seen or, when it is seen, it is regarded as something we knew all along—which I, for one, don't believe we did.

Through the cooperation of the Hanover Institute, a complete set of these demonstrations is now part of the Office of Public Opinion Research in the Department of Psychology at Princeton and a few of the demonstrations, together with a laboratory manual, are being currently used with great success in the laboratory periods which are part of our introductory psychology course.

Some experimentalists who have gone through the demonstrations with me at Princeton have wondered why a social psychologist and someone who is occasionally labeled as a mass movement or public opinion specialist, should be interested in demonstrations which to them seem chiefly concerned with an explanation of how and why we get our experience of depth perception. The answer is, of course, that a clear understanding of perception itself (no matter what the specific perceptual problem may be) has just as much relevance for someone concerned with the nature and significance of attitudes and opinions as it does for someone whose chief interest may be the time error or size constancy. For principles of psychology, once we discover them, must—if they are principles—be applicable to all of man's experience whether this takes place in the laboratory, in the clinic, or in everyday social life.

I have gone out of my way somewhat to pay tribute to the work of Mr. Ames because my own discussions with him and the various research programs now under way at Princeton involving his demonstrations are inevitably reflected in the remarks to follow. I find it difficult, almost impossible, to know where to begin a discussion on the nature of social perception or, for that matter, any other topic in psychology. I seem to start my course in social psychology with a different topic every year, hoping that some day, through experience, I shall find out what really should come first for purposes of communication and understanding. So many variables are interrelated. I shall, then, have to touch briefly here on a number of variables involved if I am to communicate to you what seems to me to be the proper understanding of the term, social perception.*

The Nature of Perception. Since "social perception" can be understood only in so far as we understand the nature of perception, it will be necessary first of all to indicate what formulation of perception seems to make the best sense. If this formulation appears to be somewhat radical, it may be because the approach is 100 per cent functional, not limited to perception as a study of a series of quantitative relationships. The demonstrations, together with other evidence from experimental and social psychology, seem to point to some such interpretation as the only one that will eventually give us some clarification of the role of perception in purposive behavior. Here I can only sketch in barest

* A more detailed elaboration and a more general formulation of the present discussion will be found in: **Cantril, H.** Understanding Man's Social Behavior: Preliminary Notes. Office of Public Opinion Research, Princeton, N. J. 1947. Some of the present discussion concerning the nature of perception and social perception is taken from that little book.

outline some of the characteristics of perception that must be taken into account in any valid and adequate interpretation.

First of all, it seems clear that any perception is an awareness that emerges as a result of a most complicated weighing process an individual goes through as his mind takes into account a whole host of factors or cues. It must be emphasized at the very outset how tremendously complex even the simplest perception is—for example, the perception of a star point. For it can be demonstrated that, in perceiving a star point as such, a whole host of indications are weighed and integrated to give us our final experience. Among these indications are those related to the environmental conditions just prior to and during the visual experience of the point, together with all the past experiences we have had with similar stimuli which have built up in us a sort of statistical average used as a frame of reference for our interpretation of the concrete stimulus of the moment.

We must also remember that the integration of all these factors is accomplished in a fraction of a second and is, more frequently than not, entirely unconscious. As the stimuli from outside become more complicated, running, for example, from a star point to lines, to three-dimensional objects, to objects in motion, to persons, or to a newspaper headline describing an international situation, the number of factors which must be integrated runs into many thousands.

At the turn of the century, Mayer and Orth apparently surprised many of their colleagues when they pointed out that a judgment results from mental processes that are *unanschaulich*. A few years later, in 1903, Orth used the term *Bewusstseinslage* to help describe the condition or the set the mind assumes in coming out with a correct intuitive judgment, the actual details of which elude introspection. Ach's term *Bewusstheit* described essentially the same "impalpable" aspects of consciousness. These were bold and significant statements. But while the Würzburger professors did, in a sense, show us what perception was not, their approach seemed to end in a blind alley, for no new positive understandings emerged as to what perception actually was.

From our present vantage point, the observations of Helmholtz concerning the nature of perception take on special significance. In the third volume of his *Physiological Optics*[3] with its chapter 26 entitled "Concerning the Perceptions in General," Helmholtz makes it quite clear that our perceptions are based not only on past experience but are discriminative and accurate largely in so far as "they are useful in enabling us to recognize external objects" (p. 6). Throughout this chapter, Helmholtz emphasizes what he regarded as a fact: that perceptions function only in so far as they serve the organism in the process of adjustment.

It appears that the significance of Helmholtz's contribution in this field was largely lost sight of in the great scientific arguments which immediately followed his death and continued for years on the relative merits of his empirical theory and Hering's nativistic theory. The force of Helmholtz's arguments can now be concretely experienced in the Ames demonstrations.

In addition to the fact that perception seems clearly to result from the weighing and integrating of a whole host of factors and that the factors introduced into this weighing process are those which have been learned largely unconsciously from past experiences, it appears that a good deal more emphasis must be given now to other characteristics of perception implicitly recognized by Helmholtz but not explicitly elaborated by him. The first of these factors is what we may call "purpose," a word about which I shall say a bit more later on. For it seems obvious that the process of reaching a value-judgment, the unconscious weighing that man's brain is able to make of numerous cues during a fraction of a second, is by no means a random and chaotic procedure.

The weighing process, resulting in a perception, goes on for a purpose, whether that purpose is seeking food, adjusting one's footsteps to a curbing, picking up a book, reading or underlining certain passages in a book, joining some gang or group, or accepting or rejecting some political ideology.

In addition to the variable of purpose, it seems clear that this unconscious weighing of cues built up or learned from past experience is brought into operation when some stimulus is related by the organism to some purpose. It is also obvious that purpose can only be achieved through action.

In brief, then, perception itself is part and parcel of purposive activity. It is an emergent co-product of purposive activity and can not really be understood except in that context. We may define a perception, then, as an implicit awareness of the probable consequences an action might have for us with respect to carrying out some purpose that might have value for us.

From this definition of perception, it follows that what we have in mind or what we perceive "now" is almost invariably related to our expectancies for the future, whether this future is the probable consequences of our actions within the next fraction of a second or the probable consequences our actions of the "now" may have for us twenty years hence. Expectancy is our present reaction to the future in terms of what will happen to us if we do (or don't do) certain things now. Stated more precisely, expectancy is the psychological co-product of emerging purpose when related to potential action in carrying out that purpose in concreteness. It is within a context of expectancies that we perceive, judge, feel, act, and have our being. Your own introspection will show you that nearly all positive values of life are related to your expectancies. Without expectancies, you cease to function as a human in being, become static, and are no longer plugged in with the changing, emerging concreteness around you.

It should, perhaps, be pointed out that when the role of expectancies is added to the role of past experiences in determining perception, the "immediate present" becomes much less significant than it is considered to be by gestalt psychologists. Without ignoring the role of so-called "autochthonous" factors in some perceptual groupings, the point of view outlined here requires the introduction of other factors in accounting for the *why* of what gestalt psychologists term "relational determination" and in explaining *why* various cues such as brightness, size or overlay function as they do to help give us our sense of distance.

Perception, as such, simply cannot be understood unless perception in any concrete situation is regarded as a process that occurs in a time continuum that connects the past with the future. Unless the dimension of time, including the experience of the past and the expectancies of the future, are included as basic factors in determining the emergent perceptions we experience in everyday life, gestalt psychology seems to be put in the strange position of denying one of its own fundamental premises, *viz.*, that the whole is greater than the sum of its parts.

Action, purpose, and expectancy are, then, all intimately tied to each other as factors involved in any perception. When they are tied together, it becomes a relatively easy matter to account for the feeling of surety or lack of surety that accompanies perception. We experience a sense of surety in our perceptions if they have in the past proved to be reliable guides to purposive actions. Actions that persist, such as instinctive behavior, reflexes, habits, or conscious and deliberate efforts, do so because they have proved their adaptive value. On the other hand, we experience a feeling of insecurity, an overtone of anxiety when we are able to make only a low prognosis of the probable consequences of our future actions with respect to carrying out a purpose. Furthermore, we experience a lack of surety

when conflicting cues are introduced in the weighing process. This can be very dramatically shown in the Ames demonstrations and is experienced in everyday life when we encounter new environments in which we have not yet learned, through concrete action on our part, the significance of various cues. Thus, the city dweller will experience lack of surety when he takes his first hunting trip in the big woods, the landlubber will find it difficult to estimate the size or distance of ships that pass his own in mid-ocean, a Southern gentleman may not know exactly how he should behave in the presence of a deeply pigmented man who wears a high turban and speaks a strange language. Surety of perception is also obviously affected by surety of purpose, by the relative significance to the individual of alternative goals.

Surety of perception, for whatever reasons it is established, is, of course, reflected in the speed and consistency of judgment and action. The effect of the surety of judgment on reaction time was demonstrated, for example, in an experimental study made by the author[2] in 1931 which showed "the positive correlation between an individual's degree of acceptance of a particular evaluative attitude and his speed of association time to words which have reference to that attitude" (p. 92). The effect of the surety of judgments on the consistency of behavior was shown, for example, in Jack's study of preschool children where he found that systematic training in the use of play materials and the psychological co-product of greater self-confidence would produce consistently ascendant responses in children formerly non-ascendant in the same situations.[5]

It is a well-known fact, established in numerous studies in a variety of fields, that the characteristic selectivity and discrimination involved in any perception is dependent on the referential framework built up from concrete past experiences. But the functional role of these perceptual frameworks as guides to action in carrying out the organism's purposes has by no means been sufficiently clarified.

It is, of course, in this connection that the Rorschach tests, the experiments of Murray and his co-workers on apperception, the studies of Murphy and others on autism, and the more recent studies of Bruner and his associates are significant. When we say that all of these studies unequivocally demonstrate how our experiential world, our perceptions, are affected in a major way by our purposes, what do we mean? We can only mean that, if we have learned from our past experience—which includes our own action in checking the reliability of our perceptions —that stimuli have the possibility of various kinds of significance (and there are apparently precious few, if any, stimuli which do not have such a possibility), then we will perceive the particular significance in the stimulus which has been consistently related to the achievement or the denial of our purposes. The perception of this particular significance, if not checked or counteracted by other cues, will lead to the familiar "distortions" of the "objective" external stimulus.

This phenomenon is found in a wide variety of everyday life situations as well as in laboratory experiments or in the psychiatric clinic. Our understanding of this and all other perceptual phenomena will obviously be precise only in so far as we can clarify what we mean by "purposes." It is quite impossible to go into any detailed discussion here of what I mean by the term. However, I must at least point out that I refer not only to man's instinctual needs or physiological tension systems or system, but also to specific and learned status or ego-strivings. The specific directions an individual's ego-strivings take as he tries to satisfy instinctual needs or physiological tension systems, can be analyzed in terms of their functional significance to the individual through a knowledge of his developmental history. Here, the ethnologists, the sociol-

ogists, with their excellent case studies, and the child psychologists immeasurably contribute to our understanding. Laboratory experiments, such as those of Sherif which demonstrated how the significance attached to a stimulus could be affected by experimentally induced group norms, substantiate the interpretations we can arrive at from more everyday life analysis.[6]

Yet, without in the least minimizing the importance of finding out all we can about man's instinctual needs, his tension system and the way in which men in different societies or sub-groups acquire specific ego-strivings and specific directions for their behavior, I feel certain that these tasks are *relatively* easy and that, even when accomplished more satisfactorily than they are now, the psychologist will still be left without an adequate motivational scheme. The *why* of much of man's most characteristic behavior, including his status and ego-strivings, will still be unexplained. I am convinced, therefore, that psychologists concerned with an understanding of what purpose is must seek out all the information they can from the most competent biologists and geneticists concerning man's unique pattern of growth with the emergent characterisics that have appeared in the course of evolution. I feel confident that, once man's pattern of growth is understood in the distant future, it will be found to be composed of a great deal more than instinctual needs or physiological tension systems. In addition to these, and in addition to man's obviously superior capacity for rational and abstract thinking, for concept formation, for the construction and use of artifacts, I have a feeling that *the* characteristic of man will be revealed as an urge for improvement, a desire to develop directionally. Only when this emergent characteristic is taken as part and parcel of man's distinctive pattern of growth can we satisfactorily understand man's purposive strivings. Our explanation must, of course, be entirely naturalistic.

In this connection, it gives a psychologist some comfort to read a statement by the eminent biologist, C. Judson Herrick, that "the thing that is most distinctive about man is the *pattern* of his growth and the instrumentation of it by a rationally directed desire for improvement."[4] It is to be earnestly hoped that the revived interest in the study of evolution, as reflected in the new international journal *Evolution,* with its distinguished editorial board, will hasten the psychologist's understanding of causality and increase his sensitivity to the necessity of extending enormously the time range in which he usually considers causality. A better understanding of man's characteristic pattern of growth, rooted in chromosome activities, will, no doubt, also reveal in more detail why, in addition to characteristics peculiar to human beings as such, each particular human being (identical twins excepted), has the unique qualities reflected in his particular capacities and in his temperament.

The individual, in acting to carry out his pattern of growth, both as a human being and as a particular human being, learns particular ways of acting which are comparatively standardized, statistical averages used by others for interpretation. He learns the possibilities available and the consequences of acting in different ways—punishment and reward, acceptance and rejection, etc. If the socially approved possibilities help him carry out his purposes, then these socially approved possibilities become *his* purposes. Those attitudes which have been accepted as a means of satisfying purposes define the individual's status, his loyalties, etc. If the socially approved possibilities do not satisfy an individual's purposes, he becomes maladjusted, or he seeks other means of satisfying his purposes, possibly deviant means such as gangs or membership in an emerging revolutionary group.

Anyone who has been brought up in the school of rationalism, who believes that reason is superior to perception as a guide to action, must have been wondering for

some time if, when, and how the role of rational thought and abstractions was to enter into this discussion of perception. The picture would certainly be most incomplete if we failed to indicate, although necessarily briefly, how rational thinking, logic, or acquired intellectual knowledge affects perception.

The precise function of knowledge or reasoning may perhaps be better understood if we review the up-to-the-now ideas or abstractions most laymen have concerning the nature of perception. First of all, we are apt to believe that our knowledge discloses to us what something is and how we can act concerning it; that is, we believe that our actions are determined by our knowledge. Second, we may tend to believe that our perceptions disclose to us what something is and how we can act concerning it; that is, we tend to think that seeing is believing. Third, we may tend to think that knowledge and perception are identical and that we can make the same use of them. However, the psychologist knows and the Ames demonstrations dramatically show that our actions are determined primarily by our perceptions and not by our knowledge. A social psychologist has ample evidence that information, as such, often has very little effect in determining the *direction* of opinion and action.

During the fraction of a second in which most perceptions occur, the number of factors that must be taken into account by an individual are so numerous and so varied that they cannot possibly be considered on a "logical" or "rational" basis in consciousness. I have already referred to the weighing process an individual goes through by the term "value-judgment." This process is largely unconscious, often described as "intuitive." It is easy to observe from one's own introspection and from observation of others, that no successful person bases his life on pure logic or reason—on stepping from one logical conclusion to another. Those people distinguished for their success at any time or in any field are also distinguished for their ability to make value-judgments, not simply for their I.Q.'s and their conscious rational thinking.

It would, however, be the grossest error to conclude that reasoning or knowledge has nothing to do with perception. For the tools characteristic of man's mentality, such as his ability to use concepts and abstractions, although in themselves not sufficient guides for future actions, can, nevertheless, enormously help man carry out his purposes. We need only look at the abstraction of time or the abstraction of tridimensionality to realize how much more efficiently modern man can run his complex life by using them to aid his orientation. Although it appears that we react in terms of our perceptions and not in terms of our knowledge or our conscious logical thought processes to most of the concrete situations we meet in everyday life, knowledge and reason are nevertheless powerful tools to help us get a clearer idea of the true nature of things. Knowledge seems to be particularly indispensable in providing man with the possibility of understanding why his actions have failed to accomplish his purposes. Knowledge, reasoning, and logic enable man consciously to bring more and more cues into the process of value-judgment, thus increasing the reliability of his prognosis.

But it appears that the reliability of our perception as prognostic indicators for purposeful action can only be tested finally by concrete action that we undertake ourselves. True understanding, as opposed to knowledge, seems to be the result of action which we have carried out for a purpose and which checks a perception. Understanding must never be confused with knowledge. Our knowledge helps to guide our actions accurately only in so far as we can make functional use of it. It is obvious that no matter how much knowledge you may have of a subject—whether it is psychology, politics, or anatomy—or how talented you may be, successful purposeful action requires experience and practice on your part. As we have indicated earlier,

action gives us a sense of surety, a sense of surety achieved only after we have successfully met frustrating situations. Hence, a person can have no real wisdom in a field where he has no concrete experience. When the disciples asked Christ why he spoke in parables, his answer was "Because they seeing see not; and hearing they hear not, neither do they understand."

Social Perception. After this exceedingly long introduction, we may finally be in a better position to consider the topic of social perception. I should like to repeat what was pointed out earlier, namely, that because a distinction is made between perception and social perception, there is no implication whatever of any inherent differences between the two. I use the word, distinction, in the dictionary sense of the term as "giving special recognition to" certain factors that seem to me to enter into social perception. But there is no "going beyond" any psychological principles that do not apply to the simplest visual perception.

The characteristic factor in a perception we may label "social" is that the functional activity giving rise to the stimulus has a potentiality of affecting our purposes and being affected by us. This potentiality is, of course, our own awareness. And this means that we may impute purposes to stimuli which may have no demonstrable basis, as is the case in animistic thinking. A hornet, a man, a political ideology, may be stimuli for "social perceptions" since they may do something to us or for us and we may do something to them or for them. On the other hand, lightning may be considered a "non-social perception" for it can do something to us while we can do nothing to it. A pencil can be regarded as a "non-social perception" because we can do something to it while it cannot itself do anything to us. If we are not aware of the potential cross-effects of our purposes and the purposes of other organisms, we have no "social perception" in this sense. For example, our intellectual awareness of some distant African tribe, a knowledge we may have of its economic and social structure may be for us a non-social perception as contrasted to our awareness of a European country.

In other words, the functional activity that gives rise to what we may label a "social" perception appears to us to have an important characteristic or "attribute" not part of a "non-social" perception. The "content" of perceptions we may call "social" is likely to be of vastly more significance and importance to us than the content of most non-social perceptions, *i.e.*, color, size, etc. If this formulation of the problem had been made in Külpe's time, I suspect we would be somewhat further along in our understanding of social behavior and might have been spared the artificial division that has so often separated "experimental" from "social" psychology and has been reflected from time to time in a mutual lack of appreciation of the problems and research that constitute the other fellow's area.

This distinction between perception and social perception is the only one that seems to me now to make sense. And it does seem worth while to make a distinction because the implications arising from the added factor of a two-way relationship in a social perception are important for our understanding of man's social behavior. What we may label a "social" perception generally has much greater complexity than a non-social one because of the new factor, *viz.*, the potential purposes of something else, that must be taken into account in the weighing process.

It should be noted that a social perception, as used here, has nothing to do with the inherent (atomic) nature of the source of the stimulus which may be a person, a cow, a symbol, etc. Nevertheless, for most of us, what we can label our "social" perceptions involves other people whose purposes have a potential influence on our purposes. Hence, these perceptions are especially characterized by affective or emotional overtones.

Any perception where the source of the stimulus consists of other individuals is likely to be a "social perception" as used here because of the potentiality which the purposes or actions of those other people have for affecting the carrying-out of our purposes, and the possibility of our purposes affecting the carrying-out of theirs. Other people may be judged in terms of such purposes as: Is he a rival for my girl? Will he take my job away? Will he help me get ahead? Will association with him raise my status or lower it?—etc. These are specific purposes, all of which derive from, are rooted in, man's characteristic pattern of growth. They are cultural or situational derivatives or expressions of this pattern of growth with its distinctive human psychological characteristics. But whatever the environment you have created from the particular stimuli afforded you in your developmental processes, your perceptions as a hunch for purposeful action are given in terms of the possible or probable bearing of concrete stimuli on you, such as the person in front of you, on the carrying-out of your purposes.

Since man's specific purposes are largely derived from the group loyalties and the social norms he acquires, as pointed out earlier, what are "social perceptions" for some people are not "social perceptions" for others. For example, those who believed in animism, perceived objects and forces of nature as things with purposes of their own which could affect human purposes. Anthropologists and sociologists have accumulated ample evidence of the different ways people see things in different cultural groups. And just as lightning was something Benjamin Franklin perceived in a different way than did others of his day, so certain things now believed by some people to be directed to the furtherance or frustration of their personal motives (*e.g.*, "acts of God") may lose their personal reference as man's understanding of nature and of human nature increases. The change in many of our perceptions since the advent of evolutionary theory is a case in point. And as new group loyalties are acquired or as loyalties change, the pattern of what we are distinguishing as social perceptions also changes. For example, the adolescent boy who becomes a member of a neighborhood gang, will then see certain other boys or certain adults as threats or aids to his own newly acquired purposes; American bomber pilots during World War II were reported to have lost much of their anti-Negro prejudices after participating in bombing missions during which they were ably protected by Negro fighter escorts.

This means that one reason for the necessity of understanding between human beings is that only through the mutual disclosure of purposes can we increase the reliability of the prognosis of our perceptions for successful individual action in carrying out our own individual purposes. Or, conversely stated, we will be unsuccessful in carrying out our purposes to the extent that we are unaware of the purposes of others with whom we are associated. Thus, we can cooperate with others only to the extent that our actions in carrying out our purposes help them carry out their purposes. This has apparently been recognized by nearly all the prophets. Hence, on the level of action, nearly all prophets have insisted that we do unto others as we would have others do unto us.

An effective process for understanding another's purpose apparently exists in the mutual recognition of the emergent value-qualities that are consciously experienced when two or more persons participate in joint action furthering a mutually recognized common purpose. A possible explanation of the nature of the mutual interpenetration that operates under such conditions may be the mutual disclosure of the mutual similarity of the highly integrated subconscious processes. These are revealed by the correspondence and similarity of emergent value-qualities. These emergent value-qualities are, as was mentioned before, largely products of subconscious processes.

Our capacity to meet and to adjust to other people's purposes is dependent on our ability to understand these purposes of others. We can understand others' purposes in proportion as we refuse to assign abstract motives to people and in proportion as we deal with them in concrete, emerging situations. For this alone can give us more reliable prognoses as we act on our perception of their purposes in concrete situations that test and modify our perception accordingly.

This implies that our understanding of ourselves, as we acquire it from the activity we label "introspection," is dependent, to a large extent, on our conscious understanding of the purposes of others who are affecting or who might affect our own perceptions, behavior, and purposes. If we have acquired certain status by reason of birth, then whole groups of people may be abstracted out as threats to us—such as Negroes for some Southern whites, labor for the industrialist, and the industrialist for labor. Such people or groups become abstractions. We do not distinguish between their members, nor does it even occur to us that we and they share common purposes as human beings.

Man's unique ability to carry on abstract thinking, to use concepts and reasoning, furnish him, as we have pointed out earlier, with the possibility of bringing more and more factors into the process of value-judgment itself. It would seem that it is especially in the area of complicated social perceptions that man has maximum opportunity to use his unique capacity to bring into the weighing process an awareness of the purposes of others who may be affected by his actions. Furthermore, social perception, especially, is not limited by time and space, involving as it so often does poeple not immediately present.

The relative unsureness of our expectancies in social life is apparently due chiefly to the characteristics of social perception—the potentialities of interaction between our purposes and the purposes of others. As we take into consideration not only the potentialities of this interaction, but also the potentialities of the interaction of the purposes of other specific individuals or groups on still other specific individuals or groups, and the potential simultaneous reciprocal effects of our actions on various individuals or groups, the complexities and relative uncertainties often involved in some social perceptions can be seen to increase rapidly.

Because most of man's purposes must be worked out in a social context, it is in the area we have labeled "social perception" that expectancies become particularly important—the expectancies we have concerning our friends, our co-workers, our competitors, the probability of a depression, the potential reward from superiors, etc.

From the point of view of the discussion here, an "ego-involved attitude" is an attitude catalyzed by a stimulus that can either help or hinder us in carrying out our purposes. Loyalties are ego-involved attitudes that give us a high prognosis that the purposes of others will help us carry out our purposes. A loyalty is a co-product of past experience where perceptions have been tested by action with others and have given us a high prognosis that further action with others will help us carry out our purposes, and the awareness that in carrying out our purposes we will be helping others carry out their purposes. Thus we have a high loyalty, generally, to a wife, a friend, certain groups we are members of, certain reference groups composed of persons whose purposes we believe are more or less similar to our purposes. These loyalties are a person's "my" and "our" feelings. We have no loyalty to a person, group, or symbol that does not satisfy our purposes or give us the possibility of emerging value-experience. Hence, in peace-time, in most countries, people have less loyalty to "their country" than during war-time, since there is no clear-cut common purpose to be carried out by action.

Conflict and frustration can and do occur when the learned value (*i.e.*, statistical average acquired from past experience or the abstraction handed down in the past) involved in an attitude is found to conflict with the carrying-out of a purpose by action—such as practising Christianity in a cut-throat competitive business, practising tolerance and preserving status at the same time, etc. And conflict also results when learned values which conflict with each other cannot be integrated into single purposeful action, *i.e.*, Christian virtues *vs.* unquestionable obedience to a commander or boss.

In other words, what we experience as "personal conflicts" are co-products of conflicting attitudes, of different or contradictory prognoses made when different attitudes are used as a base. Surety in social perception results when there is lack of conflict in weighing these loyalties. There is no conflict of attitudes so long as there is a common purpose between individuals. Since an individual is constantly making a choice, weighing loyalties in order to act, if he finds a choice impossible, he may somehow try to prevent the conflict from arising by putting it beyond recall, removing it from consciousness, etc. Here, problems of psychiatry can be tackled.

From the point of view developed here, it would seem that there can be a scientific basis for judging the "goodness," or the "rightness," or the "correctness" of any social perception. A perception can be called "accurate" or "right" if, through action, it has proved highly effective in carrying out a purpose, in checking a prognosis. It is imperative, however, to remember that because of the reciprocal influence of the purposes of one individual (or group) on the purposes of another individual (or group), actions will prove effective in the long run only when the purposes common to individuals or individuals as members of groups are included in perception.

Although this is a pragmatic approach, it should be clear that this formulation extends the consideration of what makes for effective action to such an extent that it is by no means identical with the pragmatism of James. "Effectiveness" of the type considered here is based on the emergence of value-quality which takes into account the community of human purposes. This completely rules out the effectiveness of a ruthless exploiter of human or natural resources.

The "morality" or "ethical" nature—the correctness or rightness—of any action, then, is to be judged in terms of the degree to which it includes and integrates the purposes and provides for the potential development of those purposes of all other people concerned in the action or possibly affected by it. In this way, the "effectiveness" of an action and its inclusion of a common denominator of relevant purposes become inseparable. Also, from this point of view, the "rightness" or "morality" of action becomes inseparable from its effectiveness. This is essentially the Christian ethic which emphasizes charity, *i.e.*, a consideration of the purposes of others. But this does not imply blind tolerance. It will also be recalled that Christ said "I came not to send peace, but a sword."

Emerging personal goals must be in harmony with emerging social goals while still emerging on the concrete individual level. What I am saying, simply, is that "what is right" means what is right for man's nature. Man alone has the intellectual capacity to understand this and to use his intellect as an aid in making value-judgments. And man alone has uncovered the evidence that ceaseless change and emergence is the rule of nature and that evolution is essentially a one-way street, essentially irreversible.[1] It is, therefore, up to man to use his unique ability consciously to plan his affairs, his production, his distribution—his society—so that individual and common purposes will be served and individual and common emergences assured.

This is not merely a moralistic note on which to end. It is a conclusion which seems to me to be based on the evidence science has provided and which follows logically from an understanding of the nature of social perception.

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SECTION OF ANTHROPOLOGY

PONAPE: A MICRONESIAN CULTURE OF THE CAROLINE ISLANDS

By RUPERT I. MURRILL*

In the summer of 1947, I was fortunate enough to be a member of the Navy-sponsored C.I.M.A. project. These letters reveal the rather ponderous title 'Co-ordinated Investigation of Micronesian Anthropology.'

It was, perhaps, the largest anthropological expedition ever to go into the field at one time, since at least twenty-one participating Museums or Universities had representatives on the project. The purpose of the latter was two-fold. First, it was a golden opportunity to study the relatively unknown area which had been dominated by the Japanese from the end of the first World War. Secondly, the participating scientists were urged to pass on any useful information they might discover, in order to facilitate relations between the present administrative powers and the natives.

Geographic Description. Ponape is a high basalt island in the Eastern Carolines, approximately 380 miles east of Truk, 900 miles south-east of Guam, 2680 miles from Honolulu and 2360 miles from Manila. The United States Hydrographic Office chart lists Ponape in the Eastern Carolines or Senyavin Islands, the latter name doubtless coming from *'La Seniavine'*, a Russian corvette under the command of Rear-Admiral Lutké who first saw Ponape in 1858.

Tradition says that people first came from the south carrying soil and built Ponape on a reef. Later, additional people came from the west and finally built the structures represented by the present archaeological ruins near Matolenim Harbor in the eastern part of the island.

* Columbia University, New York, N. Y. This lecture, illustrated by lantern slides and motion pictures, was presented at the meeting of the Section on January 26, 1948.

Ponape is about 130-145 square miles in size, with mountains in the interior rising to 2500 feet. Between the coast line and the foot of the mountains, the land is mostly flat, and it is here that the natives live. It is divided into 5 Districts—Sokas, Net, U, Matolenim, and Kitti. The Districts are divided into Sections and these into farmsteads.

Climate. The climate shows an annual average temperature of 80° F., humidity of 86%, and rain-fall around 180 in. It seems to me that descriptions in the literature of waking up at night in a pool of sweat are rather exaggerated. The humidity is not that excessive. Although rain is liable to fall at any time during the day or night, it soon soaks into the ground, and especially last summer in Districts other than Net the days were mostly clear and sunny. January-March is dry with trade winds, April-June has heavy rain fall, July-September is humid with calms and squalls.

Transportation. This is slow, since roads begun by the Spanish and Germans have never been completed entirely around the island, native paths in the interior are few, and farmsteads are scattered. Thus, one usually travels either by foot, native canoe, or by a dilapidated old Japanese diesel motorboat called a Pom-pom. A 6-8 hour journey on a Pom-pom on a hot day, overcrowded with people, piled high with bananas or breadfruit and towing several canoes, is an unforgettable experience.

Population. My main concern was to make an anthropometric study of the people of the island. In this regard, as I also took their blood pressure and examined their teeth, and as I am rapidly losing my hair, it was amusing to find myself labeled as the 'Wise Doctor.' A man with a stethoscope was obviously a doctor and the natives believe that a man who loses his hair does so because he must 'think hard.'

The native population of Ponape, numbering 5,855 as of June, 1947, may be conveniently divided into two main types: (1) 'Pure' Ponapeans—that is to say, those whose ancestry shows no mixture with whites. (2) Mixed. These can be subdivided into: a. Ponapean natives who mixed with whites, such as Americans, English, French, Germans, and Portuguese. b. Ponapean natives who mixed with out-islanders, natives from surrounding islands. c. Ponapean natives who mixed with the Japanese.

As my data have not yet been fully worked out, I am afraid that the above description, though only enough to whet the appetite, will have to suffice for the moment.

Health. Regarding the general health of the natives, the following diseases are commonest: yaws with about 90 per cent infected; tuberculosis 70 per cent; hookworm 100 per cent; gonorrhea 30 per cent of the adult population. These figures may look rather shocking, but the U. S. Navy hospital is doing a splendid job and, in due time, this picture will doubtless be altered.

Resources. Briefly, we can summarize the resources of the island as follows. Yams and breadfruit are the main subsistence crops, with many other cultivated and wild plants being used as food. There are pigs (which take delight in moving in under a house at night and disturbing one's sleep), chickens, goats, carabao, cows, wild deer, and birds. From the sea are obtained many kinds of fish, and the farmsteads and mountain forests, of course, have lumber, flowers, thatching materials, baskets, and other materials for handicrafts.

In the past, exports have included copra, bonito fish, hibiscus bast (kalau), lumber, alcohol from sugar cane, cassava, trepang (sea-cucumber), and tortoiseshell. Furthermore, there was produced for local consumption by the Japanese and natives, paper pulp, cotton from kapok trees, tobacco, rice, liquor, coffee, salt, and many fresh vegetables.

The main town of Colonia in Net District had 4000 Japanese, with restaurants, laundries, a slaughter house, pharmacy, dairy, electric lights, and telephones. However, Colonia was completely destroyed by American incendiary bombs.

The above picture is hardly the typical slumberous South Sea island usually seen in the movies.

Results of Foreign Contacts and Occupations. In the pre-Spanish period of 1826-1886, American whaling boats visited the island, with the usual results of woman-chasing and spread of disease, especially smallpox. The Boston Mission, having christianized Hawaii and looking for greener pastures, cast its eyes westward and finally reached Ponape. It successfully abolished the native religion and most dances.

In the Spanish period of 1886-1899, Colonia was made the main administrative center, roads were begun, Protestant-Catholic clan wars broke out, but more important was the fact that native institutions remained unchanged.

In the German period of 1899-1914, the building of roads continued. In 1910, the German Governor was killed in the 'Sokas rebellion.' Actually, this was another clan war, due to which the Sokas inhabitants were deported to Palau in the Western Carolines and out-islanders were brought in to take their place. Of greater lasting importance were two changes that occurred in native institutions. Whereas, in native times, a commoner held his farmstead as a tenant under the District chief, the Germans now divided the land so that each man owned his farmstead. Also, they proclaimed that land could not be divided by a number of heirs, as was formerly the case.

Under the Japanese, 1914 to 1945, the Sokas inhabitants that had been deported to Palau were returned to Ponape. The German system of land tenure was followed outwardly, but actually conflicting changes occurred. For example, the Japanese allowed land to be divided again among a number of heirs, pro-Japanese heirs were

favored, and District land formerly available to commoners for mountain farms was declared Japanese Government property. However, one thing is certain, that during the Japanese occupation the natives were economically at their highest standard of living.

After 1945, we speak of the American period. In the first year little was accomplished beyond returning natives to farms and the establishment of the Navy hospital. However, all District chiefs of higher rank now come together for monthly meetings in Colonia to discuss administrative problems. In short, we have for the first time unification of the Districts.

Building materials have been very scarce, as have been imported goods of all kinds. The reason for the lack of immediate action in this island area is perhaps largely due to the fact that the permanence of America's trusteeship in this area has not been too certain. In addition, other areas such as Japan have doubtless warranted greater attention.

In regard to the visiting anthropologists, the natives were probably somewhat impressed by the fact that a 'pseudo-doctor' was examining them all over the island. They were definitely impressed by the work of the visiting linguist, Dr. Paul Garvin, who settled the vexing problem of differences in the Protestant and Catholic native spelling systems by introducing a new spelling system that satisfied the Protestant, Catholic, and native interests.

Brief Sketch of the Ponapean's Personality. Superficially, the personality of the Ponapean is not easy to assess. I believe the reason for this is largely a historical one. In native times, boys were trained to be strong and brave to endure pain, especially for tattooing and the removal of one testicle which was part of the ritual of becoming a man, and to be a good fighter. Girls were trained to be brave for tattooing and bearing children. Today, the emphasis is to be strong, self-reliant, and a good worker.

In other words, the former overt aggressive pattern has been modified into an aggressiveness, mostly hidden, that is directed toward competition in the new sphere of prestige, that of the ownership of wealth. An economic pattern has replaced the old war pattern. However, in native times and probably to a somewhat lesser extent today, proper deference to higher titled men was and is important on many occasions. Just how much aggressiveness was concealed in native times it is hard to say.

Fitting in with the pattern of deference one finds that politeness is stressed. The form of greeting, also said on departure—*kaseleelya*—is invariably used.

Swearing, practical jokes, openly boasting, are all frowned upon, with the result that one receives an impression of modesty bordering on humility. Compliments may be given but are denied by the recipient. It is interesting that one hears much laughter but usually jokes are at someone else's expense. In a word, humor is malicious.

Shame (*namenek*) seems to me almost an obsession. If a house is not clean or a child urinates on the floor in the presence of visitors, the house-owner is ashamed. Adults are ashamed to instruct boys and girls in sexual matters. There are countless ways in which one can be shamed.

I am not sure how much of this shame is the result of Christianity, as three concepts of 'badness' are stated explicitly. *Me suwet* meaning 'bad,' *tip* meaning 'sin' (Christian), and *into* meaning 'shameful.' The latter are arranged in order of severity, the first being the least severe.

Finally, one is impressed by an over-all atmosphere of quiet dignity.

The Clan. Every Ponapean belongs to one of 22 exogamous matrilineal clans of varying size. These clans regulate marriage, are the basis of hereditary rank, and have economic and ceremonial functions. The clans are widely distributed throughout the island. Each District has certain 'ruling clans' from which chiefs are chosen, but these clans vary from District to District.

Most clans have several sub-clans which are also exogamous. Actually, the distinc-

tion between clan (*Tip* or *Sou*) and sub-clan (*Kainek*) were no longer clear to my informants. In the same District, children are taught to love their clan members. Formerly, clan wars were due to clan members aiding each other.

The clan does not help in fishing, farming, and hunting, but does form the basis of co-operative work parties; for example, to help its members build a canoe or erect a house. Clan members of other Districts only help economically by giving hospitality to traveling members.

At the death of a married man or woman, members of both clans come and sit up with the body. A feast is given and if, depending on the rank of the deceased, it is not large enough, the family of the dead person and indirectly the clan are shamed.

Political Organization. Each District is ruled by two parallel sets of 12 main chiefs with up to 10 lesser chiefs. There are Section chiefs and minor titles. In fact, everyone has a title of some sort.

The *Nanmarki* and *Naniken* are the titles of the heads of the two parallel sets of chiefs. Formerly, the *Naniken* was the administrator of all District affairs, the one who 'spoke.' The *Nanmarki* was too elevated to rule or 'speak.' Interesting parallels with Polynesia to be found on Ponape are this 'talking chief,' *kava* drinking, and emphasis on rank.

The Germans made the *Nanmarki* appear in public and manage District affairs. The Japanese made the *Nanmarki* District administrator and the *Naniken* District judge. The Americans continue to deal mostly with the *Nanmarki* although, for example, in Net District the *Naniken* is not only the most intelligent native on the island, but the most influential one in that District.

Formerly, chiefs succeeded one another progressively. If one designated the *Nanmarki* by X_1, he would be succeeded by chief X_2, X_2 by X_3, and so on, but the *Nanmarki* and *Naniken* could and did promote certain chiefs irrespective of their position in the line of succession. This progressive pattern has been modified since there are chiefs who cannot move higher because they do not belong to the correct sub-clan, also certain pro-Japanese chiefs obtained a more rapid promotion than was normally possible.

Each District still builds and owns a District meeting house and feast house. Each District is divided into a varying number of Sections, each of which has a Section chief and feast house, and each Section is divided into farmsteads occupied in turn by a household.

Ponape has no villages, since houses are separated by farmsteads. The Section takes the place of village life. However, certain out-islanders do live in villages such as Mokil village in Sokas and Greenwich village (natives from Kapingamarangi) in Net.

Rank. Three main types of rank are discernible. First is the nobility. These are persons both of whose parents are noble, and such men can become *Nanmarki* or *Naniken*. Secondly, *Seriso* are those who have only one noble parent. They are the children of marriages between nobles and commoners. Thirdly, commoners are those having no noble blood.

Actually, commoners could achieve higher status by becoming stewards to chiefs, or by marrying a noble, or becoming a Section chief. An individual's position then depends on his hereditary and achieved status.

Competition. Yams and breadfruit, although subsistence crops, are also part of a prestige economy that is independent of the commercial economy in which the primary item is the coconut.

By contributing yams to a feast (*kamatip*), a man can obtain prestige. A Section chief will keep an eye on the man contributing the largest yam, as the size of the yam counts, not the quantity, and perhaps reward him with a title. Hence, it is not surprising that yam growing is secret and so many varieties of yams exist—at least 156.

Pit breadfruit, made by ageing breadfruit in a large pit for several years, is next to yams in this prestige economy. In this case, age is important, not size. Pigs and *kava* are an indispensable part of a large feast and are always served according to rank.

A thrifty man, then, is one who deprives himself in order to present yams, pigs, etc., at a feast, yet has more left at home. A wasteful man is one who eats his own food rather than deprive himself to have plenty for a feast.

In conclusion, a new system of prestige based on wealth, as evidenced by the number of coconut trees owned, money, a new house, dishes, good clothes, has recently become in many cases more important than the older form of prestige economy. This new wealth-prestige, however, is part and parcel of the commercial economy, as it provides a stimulus for wage-earning and the production of copra from coconuts.

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9. **Kubary, J. S.** 1875. Weitere Nachrichten von der Insel Ponape. J. Museum Godeffroy. III. Hamburg.
10. **O'Connell, J. F.** 1836. A Residence of 11 Years in New Holland and the Caroline Islands. Boston.
11. **South Seas Government Statistical Yearbook.** 1938. Tokyo.
12. **U. S. Navy Department.** 1944. East Caroline Islands. Civil Affairs Handbook OPNAV **P22-5.** Washington.
13. **Yanaihara, T.** 1940. Pacific Islands under Japanese Mandate. Oxford University Press.

Note. The Section of Physics and Chemistry held a meeting on January 6, 1948, at which Professor Serge A. Korff, New York University, New York, N. Y., presented a paper entitled, *Recent Developments on Cosmic Rays*, illustrated by lantern slides and motion pictures. No abstract of this has been received.

THE NEW YORK ACADEMY OF SCIENCES

announces

TWO PRIZE CONTESTS FOR 1948

The New York Academy of Sciences announces the following prize contests for the coming year.

I. THE A. CRESSY MORRISON PRIZE CONTEST

Two prizes of $200 each, offered by Mr. A. Cressy Morrison, to be known as the A. Cressy Morrison Prizes in Natural Science, will be awarded at the Annual Meeting, December, 1948, for the two most acceptable papers in a field of science covered by the Academy or an Affiliated Society.

II. THE GEORGE FREDERICK KUNZ PRIZE CONTEST

A prize of $200, offered in accordance with the bequest of the late Doctor George Frederick Kunz, to be known as the George Frederick Kunz Prize in Geology and Mineralogy, will be awarded at the Annual Meeting, December, 1948, for the most acceptable paper in the field of Geology and/or Mineralogy.

Conditions Governing These Prizes

(1) *Eligibility.* Authors and co-authors competing for prizes in these contests shall be members in good standing of The New York Academy of Sciences or one of its Affiliated Societies, but non-members may become eligible by joining one of these organizations before the closing date.

(2) *Date.* Papers are to be submitted on or prior to October 15, 1948, to the Executive Director of The New York Academy of Sciences, at The American Museum of Natural History, Central Park West at 79th Street, New York, N. Y.

(3) *Papers.* All papers submitted must embody the results of original research not previously published. The manuscript shall be typewritten, in English, accompanied by all necessary photographs, drawings, diagrams and tables, and shall be ready for publication. Papers must be accompanied by a summary of the data presented and conclusions reached.

(4) *Awards.* The awards shall be made by the Council of The New York Academy of Sciences. If, in the opinion of the judges, no paper worthy of a prize is offered, the award of a prize or prizes will be omitted for this contest.

(5) *Publication.* The Academy shall have first option on the publication of all papers submitted, unless especially arranged for beforehand with the authors, but such publication is not binding on the Academy.

(6) Wherever and whenever published, the papers awarded the prizes shall be accompanied by the statement: "Awarded an A. Cressy Morrison Prize in Natural Science in 1948 by The New York Academy of Sciences," or, "Awarded a George Frederick Kunz Prize in Geology and Mineralogy in 1948 by The New York Academy of Sciences," as the case may be.

Such a statement, in substance, must also accompany any formal publicity initiated by the author regarding the prize paper. If published elsewhere, six copies of each prize paper must be deposited shortly after publication with the office of The New York Academy of Sciences.

THE NEW YORK ACADEMY OF SCIENCES
Central Park West at 79th Street,
New York, N. Y.

EUNICE THOMAS MINER
Executive Director

NEW MEMBERS

Elected January 22, 1948

SUSTAINING MEMBERSHIP

Levy, Martin W., D.O., Internal Medicine. Brooklyn, N. Y.

ACTIVE MEMBERSHIP

Adelman, Milton Harris, M.D., Anesthesiology, Physics, Chemistry. Associate, Mt. Sinai Hospital, New York, N. Y.

Ames, Stanley Richard, Ph.D. Senior Research Chemist, Biochemistry Department, Distillation Products, Inc., Rochester, N. Y.

Arditi, Maurice. Degrees; Electrical Engineer, Engineer-Physicist, Electronics. Engineer-Physicist, Federal Telecommunications Laboratories, Nutley, N. J.

Ball, Edwin L., Ph.D. Research Mycologist, Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y.

Bartelstone, Herbert J., D.D.S. Research Assistant, Columbia University Dental School, New York, N. Y.

Benjamin, Sidney H., Ph.B., Development of New Products. (Formerly) President, S. H. Benjamin Coal & Coke Co., New York, N. Y.

Berger, Adolph R., M.D. Assistant Professor of Clinical Medicine, Director of Student Health Service, Assistant Chief Cardiovascular Disease Clinic, New York University College of Medicine; Instructor in Physiology, Assistant Professor of Medicine, New York University College of Dentistry; Associate Visiting Physician, Associate Chief Cardiovascular Disease Clinic, Bellevue Hospital, New York, N. Y.

Berman, Martin H., D.D.S., Biological Sciences. Floral Park, N. Y.

Boggs, Fitzhugh W., Ph.D. Research Physical Chemist, General Laboratories, U. S. Rubber Co., Passaic, N. J.

Bondi, Amedeo, Jr., Ph.D. Professor of Bacteriology, Hahnemann Medical College, Philadelphia, Pa.

Borota, Alexander, M.D. Research Assistant, Skin & Cancer Unit, New York, N. Y.

Brewer, Gladys Hope, B.A., Physiology. Biochemist, American Cyanamid Co., Stamford, Conn.

Carney, Thomas P., Ph.D. Head, Organic Chemical Research Department, Eli Lilly & Co., Indianapolis, Ind.

Connell, James F., Jr., M.D., Surgical Pathology. First Lieutenant, Medical Corps., U. S. Army, Staten Island, N. Y.

Crawford, William H., M.A. Associate Dean, Instructor in Anatomy and Embalming, American Academy of Embalming & Mortuary Research, Inc., New York, N. Y.

Crohn, Edward B., M.D., Internal Medicine. Intern, Mt. Sinai Hospital, New York, N. Y.

Cutler, Janice A., Ph.D. Research Associate, Polytechnic Institute of Brooklyn, Brooklyn, N. Y.

Defranceschi, Antonio, D.Chem. Research Associate, Department of Biology, Princeton University, Princeton, N. J.

Deschamps, Ignacio, M.S., Enzymology. Research, Fordham University, New York, N. Y.

Ehrhorn, Helen, B.S. Bacteriologist, Halloran V. A. Hospital, Staten Island, N. Y.

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Eisenman, Herschel I., M.S. Fur Dyer, H. I. Eisenman, Inc., New York, N. Y.

Featherstonhaugh, Duane, B.A., Ornithology, Speleology, Photographic Chemistry. Duanesburg, N. Y.

Ferguson, Lloyd N., Ph.D. Assistant Professor, Chemistry, Howard University, Washington, D. C.

Fiore, Joseph V., M.S. Graduate Student, Fordham University, New York, N. Y.

Foss, Olav, Ph.D. Post-Doctorate Fellow, Department of Chemistry, Columbia University, New York, N. Y.

Fredericks, Carlton, B.A. Executive Director, Institute of Nutrition Research, New York, N. Y.

Friedmann, Asa B., M.D. Radiation Therapist, Kings County Hospital; Radiologist, Adelphi Hospital, Brooklyn, N. Y.

Gabrielson, Ira Wilson, B.A. Medical Student, College of Physicians & Surgeons, Columbia University, New York, N. Y.

Gewanter, Aaron Philip, M.D. Assistant Pathologist, Queens General Hospital, Jamaica, L. I., N. Y.

Gilmore, Eleanor LaVerne, M.S. Bacteriologist, Ortho Research Foundation, Raritan, N. J.

Haber, Alvin, B.A. Medical Research Assistant, Biological Laboratories, Brooklyn, N. Y.

Hagins, William Archer, B.A., Neurology, Nerve & Cellular Physiology. Acting Instructor, Anatomy, Stanford University, Calif.

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Himmelstein, Aaron, M.D., Chest Physiology, Thoracic Surgery. Assistant, Department of Surgery, Columbia University, New York, N. Y.

Hinkley, J. William, B.S. Secretary, Research Corp., New York, N. Y.

Hirshleifer, Irving, M.D. Member, Medical & Cardiac Staff, Kings County Hospital, Brooklyn, N. Y.

Höber, Rudolf, M.D. Research Professor, Department of Physiology, University of Pennsylvania Medical School, Philadelphia, Pa.

Holland, Maurice. Industrial Research Adviser, New York, N. Y.

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Kwit, Nathaniel T., M.D. Instructor, Pharmacology, New York University College of Dentistry; Associate Attending Physician, Cardiovascular Research Unit, Beth Israel Hospital, New York, N. Y.

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Svedlow, Bernard Dave, M.D. Extern, Medical Service, Montefiore Hospital, New York, N. Y.

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Vernet, Sergius, Diploma: Mechanical Engineering, Industrial Physico-Chemical Research, Biophysics, Cancer Studies. President, Vernay Laboratories, Inc., Yellow Springs, Ohio.

Victor, Joseph, M.D. Chief, Pathology Branch, Camp Detrick, Frederick, Md.

Walter, Robert I., M.D., Endocrinology. New York, N. Y.

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Widelock, Daniel, Ph.D., Bacteriology. Assistant Director, Bureau of Laboratories, New York City Department of Health, New York, N. Y.

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Woodward, Carol H., B.A. Editor of the Journal, New York Botanical Garden, New York, N. Y.

STUDENT MEMBERSHIP

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